

Measurement of J/ψ and ψ' productions in $p+d$ and $p+p$ at SeaQuest

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The partonic structure of the proton is one of the most vital topics in hadron physics. The SeaQuest (E906) experiment at the Fermi National Accelerator Lab (FNAL) in USA is aimed at measuring the flavor asymmetry of light antiquarks in the proton, $\bar{d}(x)/\bar{u}(x)$, at large Bjorken x ($\gtrsim 0.3$). It utilizes the 120-GeV proton beam from the FNAL Main Injector and targets of liquid hydrogen and liquid deuterium. The result of $\bar{d}(x)/\bar{u}(x)$ using the Drell-Yan process is being reported.^{1,2)}

The data recorded by SeaQuest include J/ψ and ψ' productions. The production cross sections of J/ψ and ψ' are sensitive to distributions of both antiquarks and gluons through the $q\bar{q}$ annihilation ($q\bar{q} \rightarrow J/\psi$ or ψ') and gluon fusion ($gg \rightarrow J/\psi$ or ψ'), as shown in Fig. 1. The $q\bar{q}$ annihilation dominates in the region of large Feynman x ($x_F \gtrsim 0.4$) where SeaQuest can measure. Therefore, the measurement of J/ψ is expected to provide additional constraints on parton distribution functions (PDFs), particularly of antiquarks at middle values of Bjorken x . Furthermore, the measurement of ψ' helps us disentangle the antiquark and gluon contributions because the ratio of the $q\bar{q}$ and gg sub-processes in the ψ' production is different from that in the J/ψ production, as evaluated by a calculation based on non-relativistic quantum chromodynamics (NRQCD).³⁾

Muon pairs from J/ψ and ψ' decays were detected

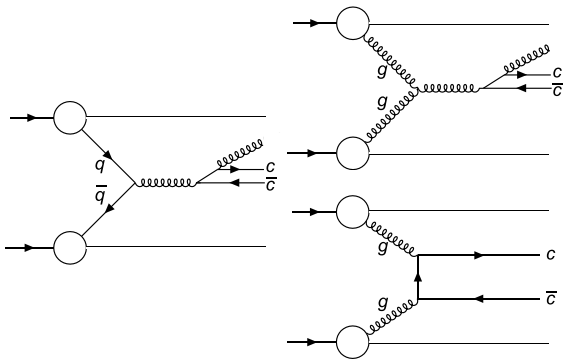


Fig. 1. Leading diagrams of J/ψ productions in proton+proton reaction.

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by the SeaQuest spectrometer.⁴⁾ SeaQuest acquired physics data from 2013 to 2017 to record 1.4×10^{18} beam protons on targets. The first half of the recorded data was analyzed. The detection efficiency of J/ψ was corrected by simulation. The beam intensity was measured with a secondary-electron emission monitor (SEM) for normalizing the $p+d$ and $p+p$ cross sections.

We have reported the $p+d/p+p$ ratio of the J/ψ cross sections.⁵⁾ It is sensitive to the relative sizes of the \bar{q} and g distributions.

On the other hand, the absolute cross section of the J/ψ production in $p+p$ is sensitive to the absolute sizes of the \bar{q} and g distributions. Figure 2 shows the preliminary result measured by SeaQuest as a function of x_F . The solid line is the theory prediction based on the NRQCD framework and the CT14nlo PDF. It shows fair agreement with the measured result. The dashed line is the theory prediction for the ψ' production. Further analysis of the SeaQuest data is underway to extract the ψ' absolute cross section.

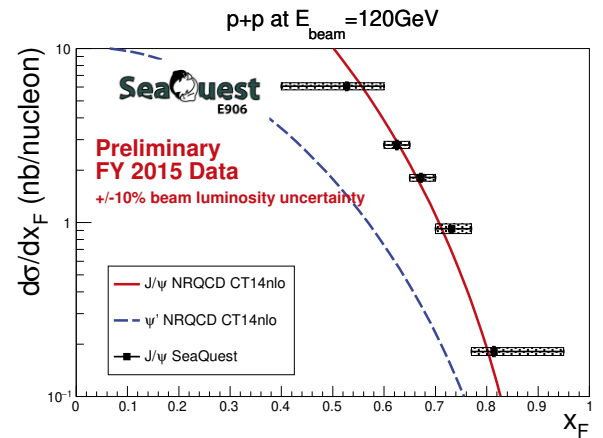


Fig. 2. Absolute cross section of J/ψ and ψ' productions vs. x_F . The points are experimental J/ψ data obtained by SeaQuest, with the statistical and systematic uncertainties drawn as vertical bars and shaded boxes, respectively. The two lines are theory predictions for the J/ψ and ψ' production.³⁾

References

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